

## DM54161/DM74161/DM74163 Synchronous 4-Bit Counters

### General Description

These synchronous, presettable counters feature an internal carry look-ahead for application in high-speed counting designs. The 161 and 163 are 4-bit binary counters. The carry output is decoded by means of a NOR gate, thus preventing spikes during the normal counting mode of operation. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the count-enable inputs and internal gating. This mode of operation eliminates the output counting spikes which are normally associated with asynchronous (ripple clock) counters. A buffered clock input triggers the four flip-flops on the rising (positive-going) edge of the clock input waveform.

These counters are fully programmable; that is, the outputs may be preset to either level. As presetting is synchronous, setting up a low level at the load input disables the counter and causes the outputs to agree with the setup data after the next clock pulse, regardless of the levels of the enable input. The clear function for the 161 is asynchronous; and a low level at the clear input sets all four of the flip-flop outputs low, regardless of the levels of clock, load, or enable inputs. The clear function for the 163 is synchronous; and a low level at the clear input sets all four of the flip-flop outputs low after the next clock pulse, regardless of the levels of the enable inputs. This synchronous clear allows the count length to be modified easily, as decoding the maximum count desired can be accomplished with one

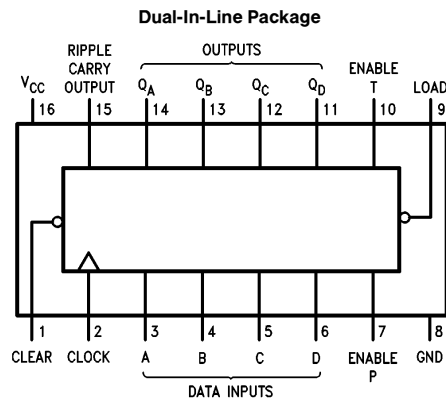
external NAND gate. The gate output is connected to the clear input to synchronously clear the counter to all low outputs. Low-to-high transitions at the clear input of the 163 are also permissible, regardless of the logic levels on the clock, enable, or load inputs.

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications without additional gating. Instrumental in accomplishing this function are two count-enable inputs and a ripple carry output. Both count-enable inputs (P and T) must be high to count, and input T is fed forward to enable the ripple carry output. The ripple carry output thus enabled will produce a high-level output pulse with a duration approximately equal to the high-level portion of the  $Q_A$  output. This high-level overflow ripple carry pulse can be used to enable successive cascaded stages. High-to-low-level transitions at the enable P or T inputs of the 161 through 163 may occur, regardless of the logic level on the clock.

### Features

- Synchronously programmable
- Internal look-ahead for fast counting
- Carry output for n-bit cascading
- Synchronous counting
- Load control line
- Diode-clamped inputs

### Connection Diagram



TL/F/6551-1

DM54161/DM74161/DM74163 Synchronous 4-Bit Counters

## Absolute Maximum Ratings (Note)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|                                      |                 |
|--------------------------------------|-----------------|
| Supply Voltage                       | 7V              |
| Input Voltage                        | 5.5V            |
| Operating Free Air Temperature Range |                 |
| DM54                                 | -55°C to +125°C |
| DM74                                 | 0°C to +70°C    |
| Storage Temperature Range            | -65°C to +150°C |

Note: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

## Recommended Operating Conditions

| Symbol           | Parameter                      | DM54161        |     |      | DM74161 and 163 |     |      | Units |
|------------------|--------------------------------|----------------|-----|------|-----------------|-----|------|-------|
|                  |                                | Min            | Nom | Max  | Min             | Nom | Max  |       |
| V <sub>CC</sub>  | Supply Voltage                 | 4.5            | 5   | 5.5  | 4.75            | 5   | 5.25 | V     |
| V <sub>IH</sub>  | High Level Input Voltage       | 2              |     |      | 2               |     |      | V     |
| V <sub>IL</sub>  | Low Level Input Voltage        |                |     | 0.8  |                 |     | 0.8  | V     |
| I <sub>OH</sub>  | High Level Output Current      |                |     | -0.8 |                 |     | -0.8 | mA    |
| I <sub>OL</sub>  | Low Level Output Current       |                |     | 16   |                 |     | 16   | mA    |
| f <sub>CLK</sub> | Clock Frequency (Note 6)       | 0              |     | 25   | 0               |     | 25   | MHz   |
| t <sub>W</sub>   | Pulse Width (Note 6)           | Clock          | 25  |      | 25              |     |      | ns    |
|                  |                                | Clear          | 20  |      | 20              |     |      |       |
| t <sub>SU</sub>  | Setup Time (Note 6)            | Data           | 20  |      | 20              |     |      | ns    |
|                  |                                | Enable P       | 34  |      | 34              |     |      |       |
|                  |                                | Load           | 25  |      | 25              |     |      |       |
|                  |                                | Clear (Note 5) | 20  |      | 20              |     |      |       |
| t <sub>H</sub>   | Hold Time (Note 6)             | 0              |     |      | 0               |     |      | ns    |
| T <sub>A</sub>   | Free Air Operating Temperature | -55            |     | 125  | 0               |     | 70   | °C    |

## Electrical Characteristics

Over recommended operating free air temperature range (unless otherwise noted)

| Symbol          | Parameter                         | Conditions   | Min      | Typ (Note 1) | Max  | Units |
|-----------------|-----------------------------------|--|----------|--------------|------|-------|
| V <sub>I</sub>  | Input Clamp Voltage               | V <sub>CC</sub> = Min, I <sub>I</sub> = -12 mA   |          |              | -1.5 | V     |
| V <sub>OH</sub> | High Level Output Voltage         | V <sub>CC</sub> = Min, I <sub>OH</sub> = Max<br>V <sub>IL</sub> = Max, V <sub>IH</sub> = Min | 2.4      | 3.4          |      | V     |
| V <sub>OL</sub> | Low Level Output Voltage          | V <sub>CC</sub> = Min, I <sub>OL</sub> = Max<br>V <sub>IH</sub> = Min, V <sub>IL</sub> = Max |          | 0.2          | 0.4  | V     |
| I <sub>I</sub>  | Input Current @ Max Input Voltage | V <sub>CC</sub> = Max, V <sub>I</sub> = 5.5V   |          |              | 1    | mA    |
| I <sub>IH</sub> | High Level Input Current          | V <sub>CC</sub> = Max<br>V <sub>I</sub> = 2.4V   | Enable T |              | 80   | μA    |
|                 |                                   |  | Clock    |              | 80   |       |
|                 |                                   |  | Others   |              | 40   |       |
| I <sub>IL</sub> | Low Level Input Current           | V <sub>CC</sub> = Max<br>V <sub>I</sub> = 0.4V   | Enable T |              | -3.2 | mA    |
|                 |                                   |  | Clock    |              | -3.2 |       |
|                 |                                   |  | Others   |              | -1.6 |       |

## Electrical Characteristics

Over recommended operating free air temperature range (unless otherwise noted) (Continued)

| Symbol           | Parameter                        | Conditions                     | Min  | Typ (Note 1) | Max | Units |    |
|------------------|----------------------------------|--------------------------------|------|--------------|-----|-------|----|
| I <sub>OS</sub>  | Short Circuit Output Current     | V <sub>CC</sub> = Max (Note 2) | DM54 | -20          |     | -57   | mA |
|                  |                                  |                                | DM74 | -20          |     | -57   |    |
| I <sub>CCH</sub> | Supply Current with Outputs High | V <sub>CC</sub> = Max (Note 3) | DM54 |              |     | 85    | mA |
|                  |                                  |                                | DM74 |              | 59  | 94    |    |
| I <sub>CCL</sub> | Supply Current with Outputs Low  | V <sub>CC</sub> = Max (Note 4) | DM54 |              |     | 91    | mA |
|                  |                                  |                                | DM74 |              | 63  | 101   |    |

**Note 1:** All typicals are at V<sub>CC</sub> = 5V, T<sub>A</sub> = 25°C.

**Note 2:** Not more than one output should be shorted at a time.

**Note 3:** I<sub>CCH</sub> is measured with the LOAD high, then again with the LOAD low, with all inputs high and all outputs open.

**Note 4:** I<sub>CCL</sub> is measured with the CLOCK high, then again with the CLOCK input low, with all inputs low and all outputs open.

**Note 5:** Applies to 163 which has synchronous clear inputs.

**Note 6:** T<sub>A</sub> = 25°C and V<sub>CC</sub> = 5V.

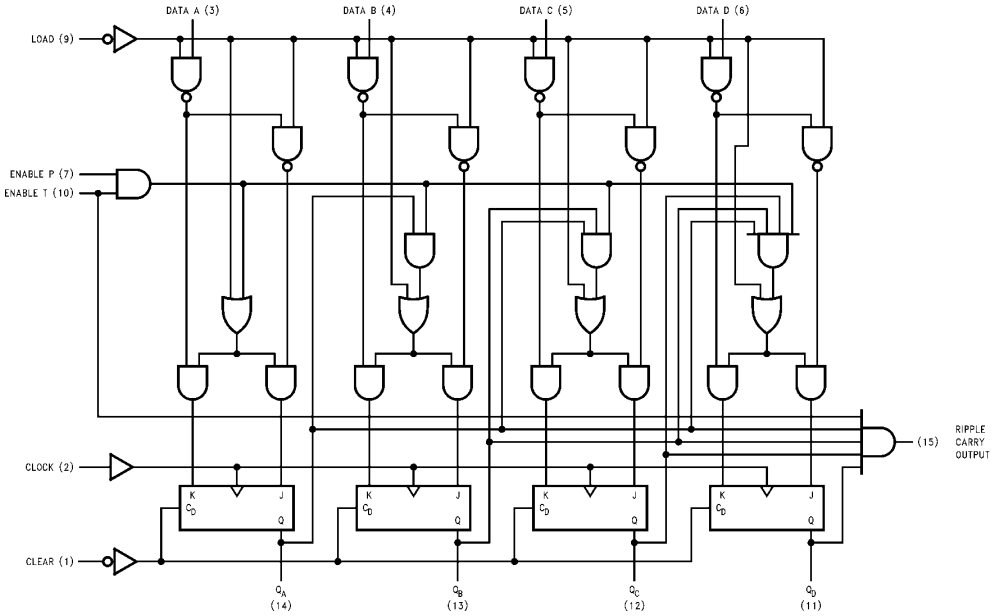
## Switching Characteristics at V<sub>CC</sub> = 5V and T<sub>A</sub> = 25°C (See Section 1 for Test Waveforms and Output Load)

| Symbol           | Parameter                                       | From (Input) To (Output) | R <sub>L</sub> = 400Ω, C <sub>L</sub> = 15 pF |     | Units |
|------------------|---|--------------------------|---|-----|-------|
|                  |   |                          | Min   | Max |       |
| f <sub>MAX</sub> | Maximum Clock Frequency                         |                          | 25  |     | MHz   |
| t <sub>PLH</sub> | Propagation Delay Time Low to High Level Output | Clock to Ripple Carry    |   | 35  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time High to Low Level Output | Clock to Ripple Carry    |   | 35  | ns    |
| t <sub>PLH</sub> | Propagation Delay Time Low to High Level Output | Clock (Load High) to Q   |   | 20  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time High to Low Level Output | Clock (Load High) to Q   |   | 23  | ns    |
| t <sub>PLH</sub> | Propagation Delay Time Low to High Level Output | Clock (Load Low) to Q    |   | 25  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time High to Low Level Output | Clock (Load Low) to Q    |   | 29  | ns    |
| t <sub>PLH</sub> | Propagation Delay Time Low to High Level Output | Enable T to Ripple Carry |   | 16  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time High to Low Level Output | Enable T to Ripple Carry |   | 16  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time High to Low Level Output | Clear (Note 7) to Q      |   | 38  | ns    |

**Note 7:** Propagation delay for clearing is measured from the clear input for the 161 or from the clock input transition for the 163.

# Logic Diagrams

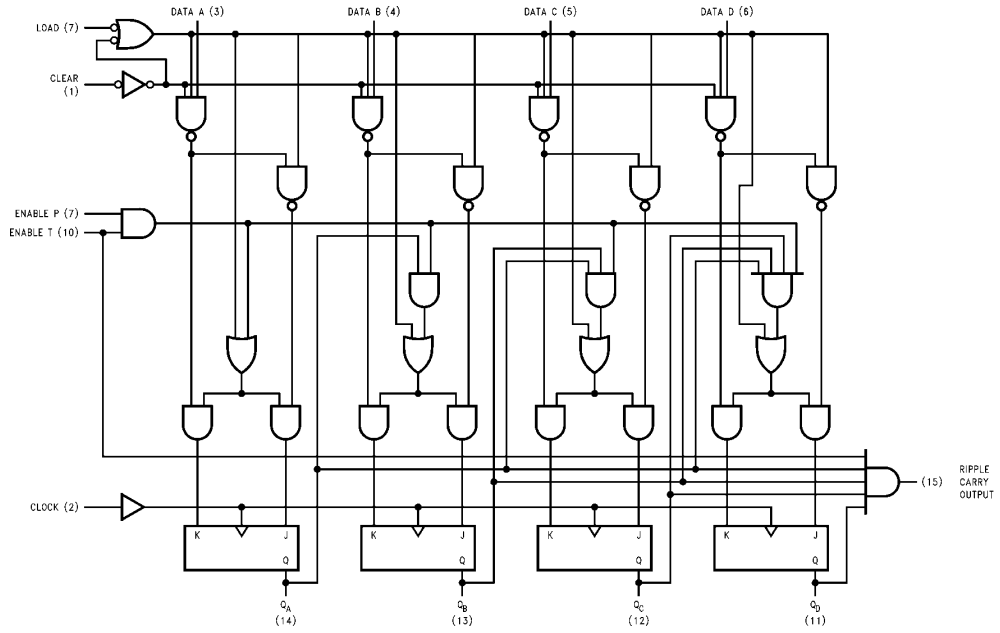
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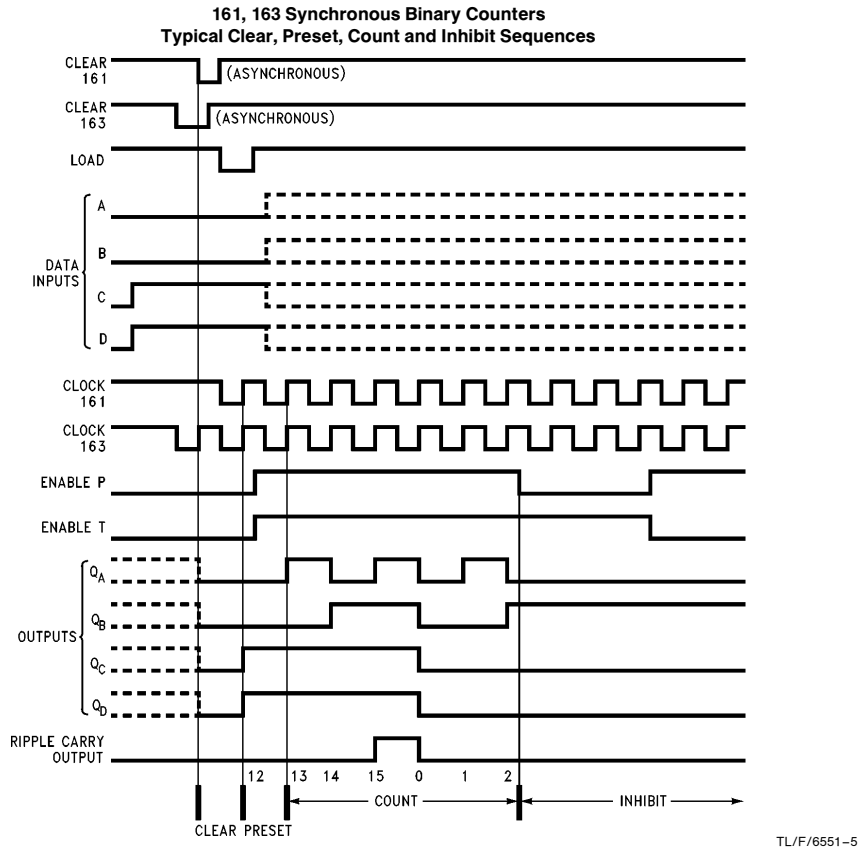
Logic Diagrams (Continued)

163



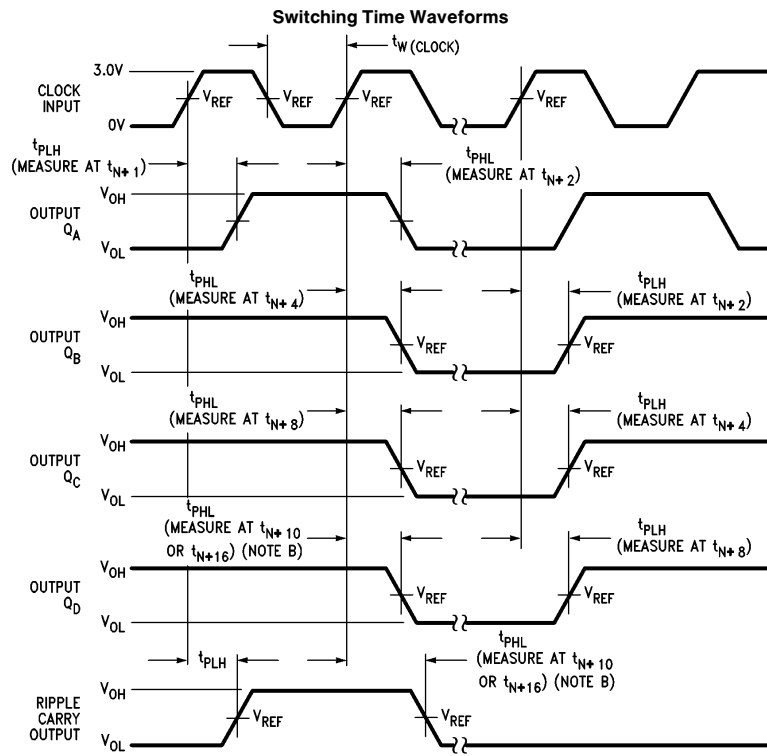
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**Logic Diagrams** (Continued)



- (1) Clear outputs to zero
- (2) Reset to binary twelve
- (3) Count to thirteen, fourteen, fifteen, zero, one and two
- (4) Inhibit

## Parameter Measurement Information



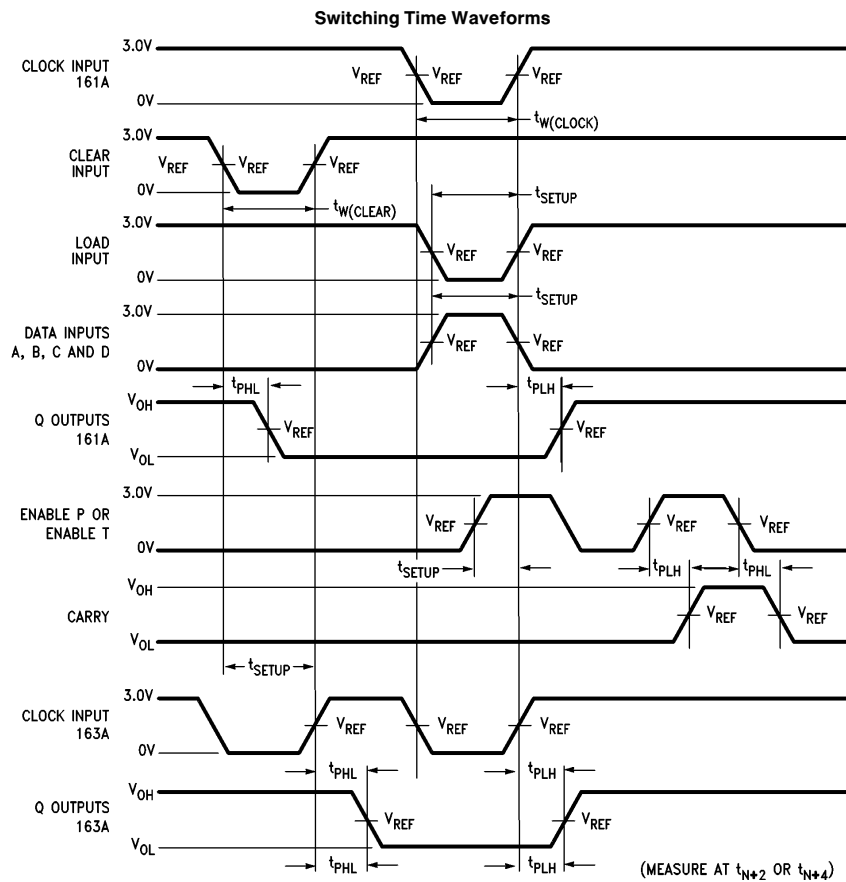
TL/F/6551-6

**Note A:** The input pulses are supplied by generators having the following characteristics: PRR  $\leq$  1 MHz, duty cycle  $\leq$  50%,  $Z_{OUT} \approx 50\Omega$ . For 161 and 163,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns. Vary PRR to measure  $f_{MAX}$ .

**Note B:** Outputs  $Q_D$  and carry are tested at  $t_{n+16}$  for 161, 163 where  $t_n$  is the bit time when all outputs are low.

**Note C:** For 161 and 163,  $V_{REF} = 1.5V$ .

## Parameter Measurement Information (Continued)



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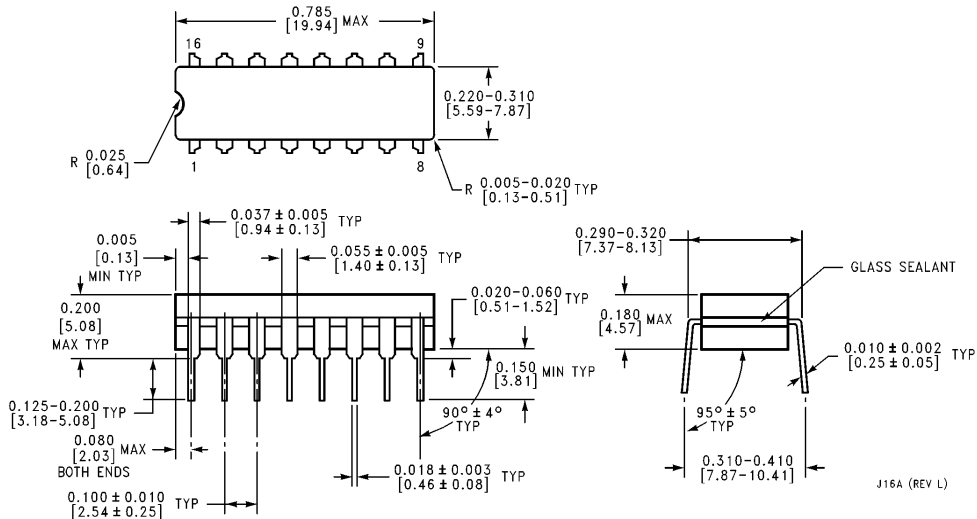
**Note A:** The input pulses are supplied by generators having the following characteristics:  $PRR \leq 1$  MHz, duty cycle  $\leq 50\%$ ,  $Z_{OUT} \approx 50\Omega$ . For 161 and 163,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns. Vary PRR to measure  $f_{MAX}$ .

**Note B:** Enable P and enable T setup times are measured at  $t_{n+0}$ .

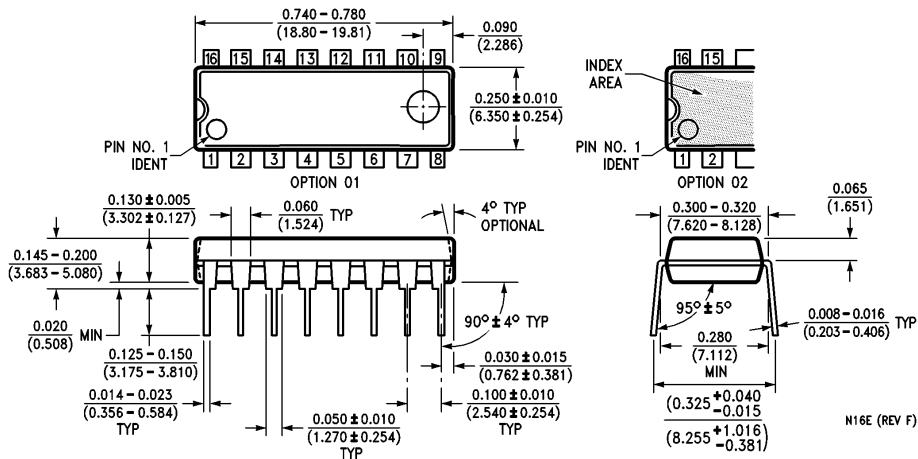
**Note C:** For 161 and 163,  $V_{REF} = 1.5V$ .



**Physical Dimensions** inches (millimeters)

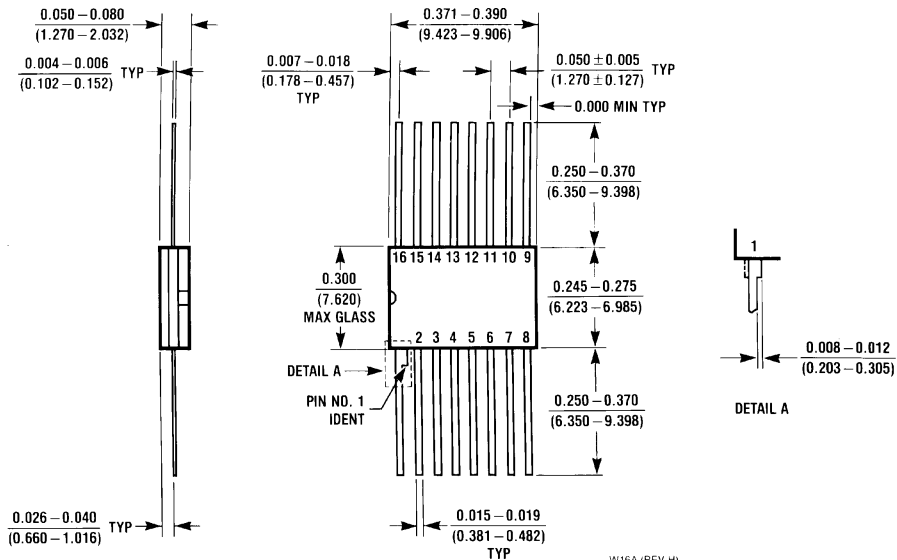


**16-Lead Ceramic Dual-In-Line Package (J)**  
Order Number DM54161J or DM54163AJ  
NS Package Number J16A



**16-Lead Molded Dual-In-Line Package (N)**  
Order Number DM74161N or DM74163N  
NS Package Number N16E

**Physical Dimensions** inches (millimeters) (Continued)



**16-Lead Ceramic Flat Package (W)**  
**Order Number DM54161W or DM54163AW**  
**NS Package Number W16A**

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